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BY

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FROM THE BRITISH JOURNAL OF PSYCHOLOGY (GENERAL SECTION)
VOL. XII. PART 3, DECEMBER, 1921

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[FROM THE BRITISH JOURNAL OF PSYCHOLOGY (GENERAL SECTION),
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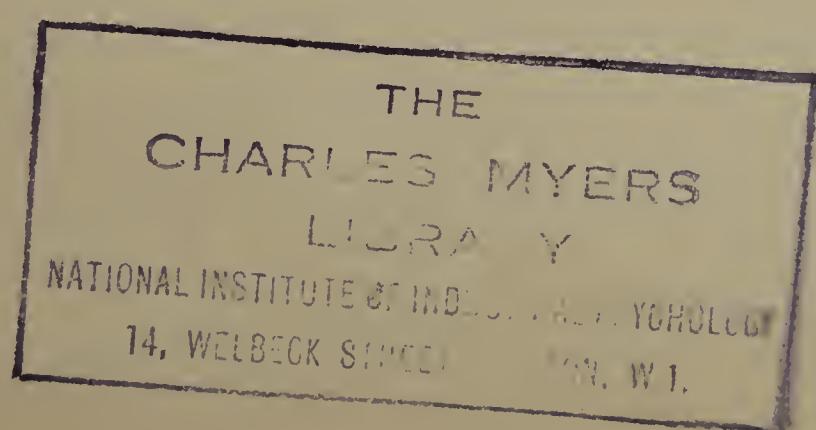
I.

THE brief series of experiments here described was conducted by one of us (C.S.M.) in 1913 on a markedly left-handed boy, whom we will call E., between six and seven years of age. His maternal grandfather, his maternal uncle, and a son of that uncle are also left-handed. The object of these experiments was to throw light on E.'s peculiar use of, and apparent preference for, the 'reversed' (*i.e.* mirrored) forms of letters and numbers. At the time E. knew some, but not all, of the letters of the alphabet, and all the ten unit arabic numbers. He had just begun to be taught to write with his right hand; but he found the greatest difficulty in doing so, owing to the coarseness and the want of co-ordination of the movements of that hand. For these reasons, and especially because he began to stutter, he was soon allowed to write with his left hand only; whereupon the confusion of the positions of letters and the disturbance of speech rapidly disappeared.

The experiments are obviously incomplete, but in view of the present interest in the subject¹, their publication seems justified. They fall into three main groups, each group dealing with a special aspect of the general inquiry. The aim of each of these groups, and the results obtained therefrom, will be described in turn. Finally, the general results and conclusions suggested by the whole of the observations will be summarised.

Group I. The experiments in this group were planned to discover how far the presentation of numbers and letters (*a*) in the 'ordinary' position, (*b*) 'reversed' (mirror fashion), and (*c*) 'inverted' (upside-down or recumbent), affected E.'s ability to read them. With this object, on

¹ Cf. H. Gordon, "Left-handedness and Mirror Writing..." *Brain*, 1920, XLIII, 313–368.



March 25, the following series of numbers (E. took a natural interest in arithmetic) was shown him:

6 1 2 4 6 7 9 3 5 2 4 7 8 9 3 5

of which those here printed in italics were drawn 'reversed.'

All were named by him with equal ease; no delay or hesitation being perceptible in naming the reversed numbers in the series. The numbers ordinarily written and in their reversed positions were described by E. as "the same, turned different ways." He could, however, be induced to choose the rightly placed numbers, except in the case of 5; here he preferred the reversed form and considered it 'right.'

Later (June 17) four series of letters, differing in length, were shown, in the ordinary, reversed and inverted positions, and the reading times were taken. These times are given in seconds, in the following table:

Number of letters in series	4	4	10	24
Ordinary position of letters	3	4	10	34
Reversed , , ,	3	3	11	34
Inverted , , ,	6	5	—	—

Thus, the recognition of letters, like that of numbers, was effected with approximately equal ease whether the material was presented ordinarily or in reversed form. Indeed, E. once remarked that "it is easier to read in the glass"! Inversion of the letters made recognition more difficult; this difficulty was felt by E. who observed: "The upside-down ones are the hardest."

Group II. The aim of this group of experiments was to ascertain how often the 'right' position would be chosen visually in the case of certain letters of the alphabet, already fairly known—b, C, D, E, h, J, K, L, S—when each of them was shown to him in different positions. For this purpose E. was given practice from March 29 to April 3, in learning to draw them with his left hand and to name them, until he could easily recognise them in their ordinary positions. At the same time two 'artificial' letters, one of which was called 'goo,' and the other 'ree,' were similarly taught him.

On April 4, May 27 and June 4, E. was required to "choose the most correct letter" in different lines, each showing a letter in varying positions, as, for instance, in the line following:

✉ E ✉ H E ✉ E ✉

On April 4 he repeatedly and consistently chose the reversed forms of b, h, and 'ree,' as being the 'right' positions. Later, however, on May 27 and June 4, after first selecting the reversed forms of E, C, D, S,

J, K, L, he chose both the ordinary and reversed forms of J, S, C and E. These forms, ordinary and reversed, were termed by him "the same thing." Indeed, he seemed quite unable to detect any difference between the two positions (normal and mirrored) of E or D, until it was suggested to him that "one looks one way, the other the other." Even then he could not decide which way these letters *ought* to look, so that he finished by saying: "I should choose both." Usually the inverted (the upside-down and the recumbent) letters were rejected; he called the recumbent forms of K and E, \bowtie and \bowtie , "upside-down."

On April 6 he was asked to write the letters h, 'goo,' b and 'ree' with his left hand (*i.e.* as they were learnt); he wrote h and 'goo' correctly, l for b, and reversed 'ree.' He considered l the "same" as b¹: "it only needs a —." His reason for reversing 'ree' is interesting: the drawing was begun correctly, but was altered to the mirrored position, because "it looks better; all the other letters face this way."

On June 4, the letter Z, previously unknown to E., was correctly learnt by drawing it blindfold with guided left and right hands, alternately. On the following day, he showed the same confusions as before; specimens of Z, whether ordinary, reversed, or recumbent, were "all zeds," when he was asked to make a visual choice; though ultimately, on his being pressed to be careful, he rejected the recumbent \bowtie (which had been his first selection) as being an 'en.' Moreover, after E. had correctly learned the unseen form of an 'artificial' letter (known to him as 'shoo') on June 4, 6 and 14, by repeatedly drawing it blindfold with the guided left hand, the *reversed* form was *visually* chosen several times on June 20 as the most correct, whereas on June 15, without practice since the previous day, he had drawn the *correct* form *blindfold* both by the left and by the right hands. So, too, the drawing of Z was *reversed* on the introduction of the *visual* factor: E.'s *blindfold* drawing of it on June 5 was Z both with the right and with the left hands, but he drew it *reversed* with either hand *when his eyes were open*².

Group III. An attempt was now made to ascertain how far E.'s tendency to visual choice of the reversed position of a letter was affected by the method of learning. With this object ten letters were taught him, (a) two letters, visually, (b) three letters, visually and with right-hand

¹ In the case of b and h, he was taught the hand-written, not the printed, form.

² In learning 'shoo' (which consisted of four short lines, each at right angles to the preceding one) by blindfold drawing, evidently E. first mastered the number rather than the direction of the successive movements. Thus, on June 6, before the day's practice, he reproduced it as four lines successively at right angles, but making a letter quite different in form from that taught him.

drawing, (c) three letters, visually and with left-hand drawing, (d) one letter, blindfold and with right-hand drawing, (e) one letter, blindfold and with left-hand drawing, until they could be reproduced correctly—blindfold, in the case of (d) and (e)—and their names were known.

This group of experiments was carried out from September 17 until October 5, various letters being practised every day; and on September 23, 25, 27, 28, 29, October 3 and 4, certain tests were interpolated. These tests were similar to those used in the experiments of Group II. At each test E. was asked to pick out the 'right' letters, pointing to his choice.

Unfortunately the results cannot be formulated quantitatively inasmuch as (i) most of the letters used had been at least partially learnt before the experiments began, and no precise information is available as to the methods or the effects of such learning; (ii) the number of repetitions needed for learning differed according to the letter; (iii) too few experiments could be made with methods (d) and (e) to have any value. But so far as they go, the data indicate the distinct (from 25 to 50 per cent.) superiority of method (a) over any of the other four methods, and the superiority of method (b) over method (c). That is to say, visual choice was more correct after purely visual learning (though even here there were 30 per cent. of wrong choices), and was more adversely affected, in the direction of preferred reversal, by left-hand than by right-hand drawing practised with the eyes open. Blindfold drawing led rather to confusion of upright with recumbent positions.

Two points, observed during these tests, are noteworthy. (i) In choosing the letter C (practised blindfold with left-hand drawing), E. was uncertain of the 'right' position, until he was allowed to run with a pencil over the variously placed letters in the test. With the aid of such left-hand tracing, the 'right' forms of the letter were chosen; whereas on subsequent right-hand tracing the reversed forms were chosen. (ii) Inversion of the test-sheet led to changes in E.'s choice—generally to choice of the corresponding reversed position. This E. explained as due to the fact that he thought that when the paper was inverted the letters must "look the other way."

II.

The foregoing experiments show that:

1. E. could read ordinary and reversed letters and numbers with about equal ease, but read inverted letters more slowly.
2. He had the greatest difficulty in deciding visually "which way a letter should go." He would frequently—invariably in the earliest ex-

periments—choose the reversed positions of letters shown him which he had previously learnt with open eyes by (especially left-hand) drawing them, although he could *reproduce* them correctly.

3. The purely visual method of learning letters was found to give the greatest number of subsequent correct visual choices, but even then only about 70 per cent. of the choices were correct.

4. The *reversed* position of a previously unseen letter or form, which E. had learnt correctly to draw *blindfold* with either hand, was preferred not only (i) on the visual presentation to him of a choice of positions, but also (ii) in subsequent drawing with either hand when the eyes were *open*.

5. After such blindfold learning of an unseen letter, repetitions of the movements by the learning hand traced over the letter visually presented in different positions enabled a correct choice to be made; whereas the reversed form was preferred when the tracing movement was performed by the opposite hand.

6. Right-hand drawing practised with the eyes open seemed to favour more correct visual choice than left-hand drawing.

7. A letter correctly learnt by one hand blindfold was not (at all events, necessarily) reversed when subsequently drawn blindfold by the other hand. *

III.

These results seem to warrant the following interpretations:

1. E.'s choice and writing of a reversed letter instead of an ordinary letter are the outcome both of visual and of manual influences.

2. A child's early visual experience is probably little concerned with the *absolute* position of seen objects. His attention is first drawn to their form, and his powers of recognition are not gravely disturbed, whether that form once learnt, be re-presented to him in the 'ordinary' or 'reversed' positions or even in the 'recumbent' or 'upside-down' positions; he apprehends the letter, as it were, in a definite visual 'schema'—through the inter-relation of its parts within the whole.

3. Whereas the visual learning of a letter rapidly permits of a simultaneous image of its parts, manual (blindfold) practice at its reproduction affords for some time at first a memory of the successive movements required to draw the letter. But finally, a *motor* 'schema' may be obtained which enables the child to reproduce the letter correctly (blindfold), even with the opposite hand.

4. But before this stage is reached, and while the visual and motor schemata are being integrated, considerable confusion must arise from

the tendency for one hand to perform the reversed (mirrored) movements learnt by the other. Especially must this confusion occur in the case of a left-hand child, like E., whose right and left hands are being both employed in writing. Since, for example, the letter E, when learnt with the right hand, is at this stage most readily written \mathbb{E} with the left, it is evident that in a left-handed child, taught to write with his right hand, and writing with his left when unobserved, a special factor is operative which tends to present him with the wrong (*i.e.* the reversed) form more frequently than in the case of a right-handed child, and so must lead to utter impotence to decide which is the 'right' form of the letter. In the case of such a left-handed child, this special factor may cause him actually to prefer the reverse to the direct forms when presented to him, especially after he has learnt to draw them correctly with his left hand; it may even lead him, when drawing with his eyes open, to reverse a letter which he has already learnt blindfold, with either hand to draw correctly.

5. The better results of right-handed than left-handed drawing with the eyes open, in the case of a left-handed child, are too difficult to interpret here.

(*Manuscript received 10 November 1921.*) *

The *British Journal of Psychology* is issued by the British Psychological Society and published in two Sections, a *General Section* and a *Medical Section*. Each Section will appear in Parts quarterly; four parts will (usually) constitute a volume of about 350 pages, Royal 8vo.

Papers for publication in the *General Section* should be sent to Dr C. S. MYERS, Gonville and Caius College, Cambridge. Those for publication in the *Medical Section* should be sent to Dr T. W. MITCHELL, Hadlow, Kent.

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